

WHAT IS CLAIMED IS:

1. An optical information recording medium comprising:
a transparent substrate having a first surface and a second surface;
a recording layer that is arranged on the first surface of the transparent
5 substrate, wherein
a hologram is recorded in the recording layer when a signal light
and a reference light are incident from an incident side opposite to the transparent
substrate, and
an optical density of the recording layer corresponding to the
10 signal light decreases from the incident side toward the transparent substrate; and
a reflection layer arranged on the second surface of the transparent
substrate.
2. The optical information recording medium according to claim 1, wherein
15 the optical density of the recording layer continuously decreases from the incident
side toward the transparent substrate.
3. The optical information recording medium according to claim 1, wherein
the optical density of the recording layer decreases stepwise from the incident
20 side toward the transparent substrate.
4. The optical information recording medium according to claim 1, wherein
the optical density $S(z)$ at a depth z in the recording layer is within a range
expressed as

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$$0.5 \times \frac{S_0}{r_0^2} \left(r_0 - \frac{A/n_1}{\sqrt{1 - (A/n_1)^2}} z \right)^2 \leq S(z) \leq 2.0 \times \frac{S_0}{r_0^2} \left(r_0 - \frac{A/n_1}{\sqrt{1 - (A/n_1)^2}} z \right)^2$$

- where S_0 is the optical density on a surface of the incident side of the recording
layer at $z=0$, n_1 is a refractive index of the recording layer, A is a numerical
30 aperture of a lens, r_0 is a radius of a spot of the signal light on the surface of the
incident side, and z is a distance from the surface of the incident side into the
recording layer.

5. The optical information recording medium according to claim 1, further comprising:

5 a groove that is arranged on the second surface of the transparent substrate to form a track, wherein

the optical density $S(r, z)$ at a predetermined position in the recording layer is within a range expressed as

$$0.5 \times \frac{S_0}{r_0^2} \left(r_0 - \frac{A/n_1}{\sqrt{1 - (A/n_1)^2}} z \right)^2 \exp\left(\frac{2r^2}{r_0^2}\right) \leq S(r, z) \leq 2.0 \times \frac{S_0}{r_0^2} \left(r_0 - \frac{A/n_1}{\sqrt{1 - (A/n_1)^2}} z \right)^2 \exp\left(\frac{2r^2}{r_0^2}\right)$$

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where S_0 is the optical density of a center of a spot of the signal light at $r=0$ on a surface of the incident side of the recording layer at $z=0$, n_1 is a refractive index of the recording layer, A is a numerical aperture of a lens, r_0 is a radius of the spot of the signal light on the surface of the incident side, r is a distance from the center of the spot in a direction across the track, and z is a distance from the surface of the incident side into the recording layer.

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6. The optical information recording medium according to claim 1, further comprising:

20 a groove that is arranged on the second surface of the transparent substrate to form a track, wherein

at a same depth position of the recording layer, the optical density of an area of the recording layer corresponding to the groove is lower than the optical density of other area.

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7. The optical information recording medium according to claim 1, further comprising:

a groove that is arranged on the second surface of the transparent substrate to form a track, wherein

30 the recording layer includes areas having different optical densities at a same depth position, and

an area having a lower optical density is arranged at a nearer position to

the groove than an area having a higher optical density.

8. An optical information recording medium comprising:

a transparent substrate having a first surface and a second surface;

5 a recording layer that is arranged on the first surface of the transparent substrate, wherein

a hologram is recorded in the recording layer when a signal light and a reference light are incident from an incident side opposite to the transparent substrate, and

10 an optical density of a part of the recording layer corresponding to the signal light decreases from the incident side toward the transparent substrate; and

a reflection layer arranged on the second surface of the transparent substrate.

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9. An optical information recording medium comprising:

a transparent substrate having a first surface and a second surface;

a recording layer that is arranged on the first surface of the transparent substrate, wherein

20 a hologram is recorded in the recording layer when a signal light and a reference light are incident from an incident side opposite to the transparent substrate,

the recording layer includes a high optical density area and a low optical density area corresponding to the signal light, and

25 the high optical density area is arranged on the incident side relative to the low optical density area; and

a reflection layer arranged on the second surface of the transparent substrate.

30 10. A method of manufacturing an optical information recording medium that includes a recording layer in which a hologram is recorded and a transparent substrate that has a first surface and a second surface, the method comprising:

depositing a first recording film on the first surface of the transparent substrate; and

35 depositing a second recording film having a higher optical density than the first recording film on the first recording film.

11. A method of manufacturing an optical information recording medium that includes a recording layer in which a hologram is recorded and a transparent substrate that has a first surface and a second surface, the method comprising:
- 5 depositing the recording layer on the first surface of the transparent substrate; and
- irradiating a light to decrease an optical density on the recording layer from a side of the second surface of the transparent substrate.
- 10 12. A method of manufacturing an optical information recording medium that includes a recording layer in which a hologram is recorded and a transparent substrate, the method comprising:
- depositing the recording layer on a surface of the transparent substrate;
- and
- 15 doping a sensitizer into the recording layer from a light incident side.
13. A method of recording information in an optical information recording medium, the optical information recording medium including
- a transparent substrate having a first surface and a second surface;
- 20 a recording layer that is arranged on the first surface of the transparent substrate, wherein a hologram is recorded in the recording layer when a signal light and a reference light are incident from an incident side opposite to the transparent substrate, and an optical density of the recording layer corresponding to the signal light decreases from the incident side toward the transparent
- 25 substrate; and
- a reflection layer arranged on the second surface of the transparent substrate,
- the method comprising:
- recording the hologram in the recording layer by irradiating the
- 30 optical information recording medium with the signal light and the reference light through a lens, wherein
- the optical density $S(z)$ at a depth z in the recording layer is within a range expressed as

$$0.5 \times \frac{S_0}{r_0^2} \left(r_0 - \frac{A/n_1}{\sqrt{1 - (A/n_1)^2}} z \right)^2 \leq S(z) \leq 2.0 \times \frac{S_0}{r_0^2} \left(r_0 - \frac{A/n_1}{\sqrt{1 - (A/n_1)^2}} z \right)^2$$

where S_0 is the optical density on a surface of the incident side of the recording layer at $z=0$, n_1 is a refractive index of the recording layer, A is a numerical

5 aperture of the lens, r_0 is a radius of a spot of the signal light on the surface of the incident side, and z is a distance from the surface of the incident side into the recording layer.

14. A method of recording information on an optical information recording medium, the optical information recording medium including
- 10 a transparent substrate having a first surface and a second surface;
a recording layer that is arranged on the first surface of the transparent substrate, wherein a hologram is recorded in the recording layer when a signal light and a reference light are incident from an incident side opposite to the
- 15 transparent substrate, and an optical density of the recording layer corresponding to the signal light decreases from the incident side toward the transparent substrate;
- a reflection layer arranged on the second surface of the transparent substrate; and
- 20 a groove that is arranged on the second surface of the transparent substrate to form a track,
- the method comprising:
- recording the hologram in the recording layer by irradiating the optical information recording medium with the signal light and the reference light
- 25 through a lens, wherein
- the optical density $S(r, z)$ at a predetermined position in the recording layer is within a range expressed as

$$0.5 \times \frac{S_0}{r_0^2} \left(r_0 - \frac{A/n_1}{\sqrt{1 - (A/n_1)^2}} z \right)^2 \exp\left(\frac{2r^2}{r_0^2}\right) \leq S(r,z) \leq 2.0 \times \frac{S_0}{r_0^2} \left(r_0 - \frac{A/n_1}{\sqrt{1 - (A/n_1)^2}} z \right)^2 \exp\left(\frac{2r^2}{r_0^2}\right)$$

- where S_0 is the optical density of a center of a spot of the signal light at $r=0$ on a surface of the incident side of the recording layer at $z=0$, n_1 is a refractive index of the recording layer, A is a numerical aperture of the lens, r_0 is a radius of the spot of the signal light on the surface of the incident side, r is a distance from the center of the spot in a direction across the track, and z is a distance from the surface of the incident side into the recording layer.